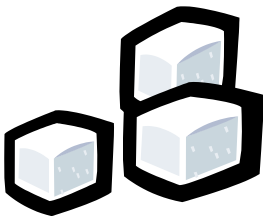
Chemistry: how sweet it is!



PART ONE: WHAT HAPPENS TO THE SUGAR?

1. Measure one cup of water and add it to the clear plastic cup.

2. Carefully drop one sugar cube into the water.

3. Watch the sugar cube. What happens to it?

4. What does the water look like around the sugar cube?

5. The sugar seems to disappear. What do you think happens to it?

6. Pour out the water and sugar as your teacher advises and rinse out the plastic cup. Measure one cup of water and add it to the clear plastic cup.

7. Measure the temperature of the water. Record this temperature. _____

8. Drop a sugar cube into the water and start the timer at the same time. After the sugar cube falls apart, you may need to use the stirring rod to scrape the sugar off of the bottom of the cup, but be careful not to stir the water.

9. Record the time it takes for the sugar cube to disappear. _____

10. Compare your results to the other groups in your class. How do they compare? Why might there be differences in the times?

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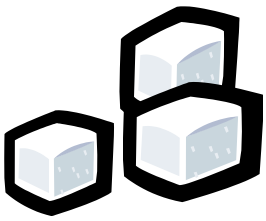

PART TWO: DESIGN YOUR OWN EXPERIMENT

1. How do you think you can get the sugar to dissolve into the water more quickly? Talk it over with your group and decide which factors you think will change the time it takes for the sugar to dissolve. List these below.

2. Think about which factors will change the amount of time to dissolve. We call these factors **variables** in science because we vary (or change) them. We need to make sure that we are testing what we want to test, so we have to change only one variable at a time and keep the other factors constant. Talk with your group and design experiments to test each of the variables you listed in #1 above. Write your ideas below and discuss them with your teacher.

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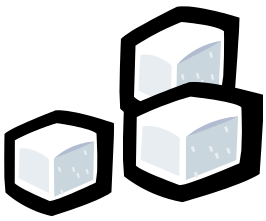
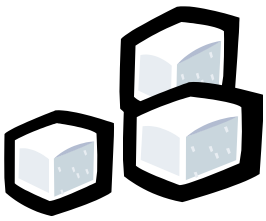


3. Carry out your experiments. Make a poster summarizing all of your results. Include what you did and the time it took for the sugar cube to dissolve for each of the variables.

4. Suppose you wanted a sugar cube to dissolve as quickly as possible. Describe how you would do it. Use your results from #3 to support your answer.

5. If you carried out the experiment like you described in #4 above, how long do you think it would take to dissolve? Use your results to predict a number and explain your answer.

6. Do the experiment you described in #4 above and time it. How long did it take? How close was your prediction?



7. Look at the other posters from the other groups. Do the other findings agree with yours? Are there any different findings? Are there new findings?

8. You now know **what** happens to the time it takes for a sugar cube to dissolve in water when you change certain variables. Now you should think about **why**. Explain **why** each of the variables you changed made the sugar cube dissolve more quickly.

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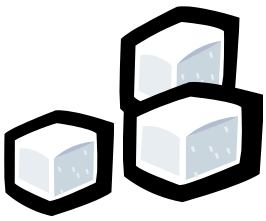

9. Let's look at one more variable – the amount of sugar in the water. Suppose you add one sugar cube to a cup of room temperature water and allow it to dissolve. Next, you add another sugar cube and start the timer. Do you think it would take more or less time to dissolve the second sugar cube than the first sugar cube? Why?

10. Carry out the experiment as described in #9 above and record the time for the second sugar cube to dissolve. Does it agree with your prediction?

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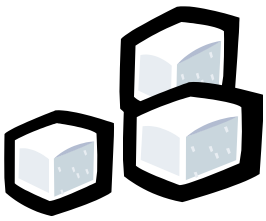

PART TWO: EXPLORING THREE VARIABLES

Now let's see what factors can change how quickly a sugar cube dissolves in water. We call these factors **variables** in science because we vary (or change) them. To make sure we are testing what we want to test, we have to keep everything else the same (or constant).

Let's first look at temperature. First, record the temperature of the water (room temperature) and the time required for the sugar cube to dissolve in Table 1 below.

1. Rinse out the plastic cup.

2. Repeat the experiment with one cup of cold water. Make sure to use one cup of water, and one sugar cube. Also, make sure to scrape the sugar from the bottom of the cup but do not stir the water. Record the temperature of the water and the time required to dissolve in Table 1 below.

3. Repeat the experiment with one cup of hot water. Make sure to use one cup of water, and one sugar cube. Also, make sure to scrape the sugar from the bottom of the cup but do not stir the water. Record the temperature of the water and the time required to dissolve in Table 1 below.

Table 1: Sugar cubes, without stirring

Temperature	Time to dissolve
Cold; temperature =	
Room temperature =	
Hot; temperature =	

4. What do you notice about the temperature of the water and the time it takes a sugar cube to dissolve?

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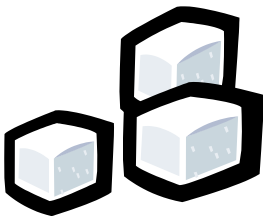

Now you know how temperature affects how quickly sugar will dissolve in water. Let's try other variables.

To make sure the other factors are the same, let's use room temperature water (take the temperature to make sure it is the same as before) and one cup of water for each of the following:

1. A sugar cube that you have crushed, without stirring (you will still need to scrape the bottom of the beaker).
2. A sugar cube in water with stirring.
3. A sugar cube that you have crushed, with stirring (try to stir the same speed as with the sugar cube that was not crushed).

Record your results in Table 2 below. First, copy the time it took for a sugar cube at room temperature to dissolve without stirring (from Table 1).

Table 2: Testing other variables (all at room temperature)

Variable	Time to dissolve
Sugar cube, no stirring	
Sugar cube, with stirring	
Crushed cube, no stirring	
Crushed cube, with stirring	

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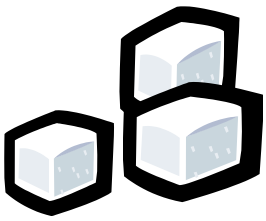


Questions:

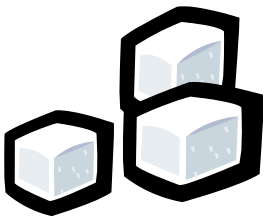
1. Which takes longer to dissolve at the same temperature with no stirring: a sugar cube or the crushed sugar cube?

2. Does the sugar dissolve more quickly or less quickly when you stir it at the same temperature?

3. You want to dissolve sugar in water as quickly as possible. Describe how you would do this (think of all the variables you tested and look at your results).

4. If you carried out the experiment like you described in #3, how long do you think it would take to dissolve? Use your results to predict a number and explain your answer.

5. Do the experiment you described in #3 and time it. How long did it take? How close was your prediction?



6. Look at the results from the other groups. Do the other findings agree with yours? List any differences.

7. You now know **what** happens to the time it takes for a sugar cube to dissolve in water when you heat the water, crush the sugar cube, and stir the water. Now you should think about **why**. Explain **why** each of the variables you changed made the sugar cube dissolve more quickly.

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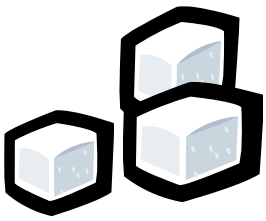

8. Let's look at one more variable – the amount of sugar in the water. Suppose you add one sugar cube to a cup of room temperature water and allow it to dissolve. Next, you add another sugar cube and start the timer. Do you think it would take more or less time to dissolve the second sugar cube than the first sugar cube? Why?

9. Carry out the experiment as described in #9 above and record the time for the second sugar cube to dissolve. Does it agree with your prediction?

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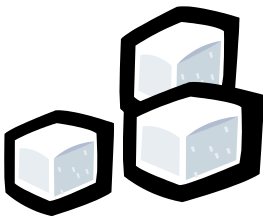

PART THREE: ONE MORE VARIABLE TO TEST

1. Suppose you placed a sugar cube in one cup of a solution of sugar water at room temperature without stirring. Do you think it would take more or less time to dissolve than the sugar cube in one cup of pure water without stirring? Why?

2. Let's try it. We have sugar solutions with different amounts of sugar. These are labeled as 20 grams per liter, 40 grams per liter, and 80 grams per liter. Carry out the experiments with the sugar again, but now use the sugar solutions. Record your results in the Table below. Record the time for pure water from your earlier results.

Table: Sugar cube dissolving in sugar water

Amount of sugar in water	Time to dissolve
0 grams (pure water)	
20 grams per liter	
40 grams per liter	
80 grams per liter	

3. How is the time for the sugar cube to fall apart related to the amount of sugar already in the water?

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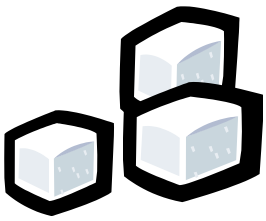


Objectives:
Students will better understand the nature of science.
Students will learn about the particulate nature of matter.

List of materials
measuring cups (to measure one cup)
hot plate or heat source (microwave works too)
clear plastic cups
thermometers
hot gloves
sugar solutions
stir rods or popsicle sticks
paper towels (for cleaning up)
food coloring
timers
sugar cubes
graph paper (optional)

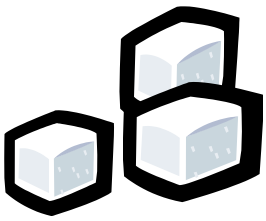
Suggested Approaches:
After Part 1 it is a good idea to discuss the observations as a class so students can answer the following:

1. Why does the sugar dissolve in water?
2. What happens to the sugar when it dissolves?

You can also use food coloring in water to show the students how food coloring acts in hot water compared to room temperature water. Seeing the food coloring diffuse more quickly helps the students see that the temperature of water is a measure of the kinetic energy of the water molecules.

Expected Results:
The sugar molecules are attracted to the water molecules. The water molecules pull sugar molecules from the sugar cube and surround the sugar molecules. When the sugar molecules are separated they are no longer visible in the water, but they are still present.

Answers will vary, but the students will probably come up with stirring the solution, heating the solution, and crushing the sugar cubes on their own. If not, you can suggest these.



Each of these changes (stirring, heating, and crushing) allows the sugar molecules to come in contact with water molecules more quickly, thus allowing the dissolving to happen more quickly.

With sugar already in solution, the sugar cubes will take longer to dissolve. This is because with sugar molecules already mixed with water molecules, there are fewer water molecules in contact with the surface of the sugar cube to pull the sugar molecules from the sugar cube.

Variations:
There are two "Part Two" sections included. The first is inquiry-based while the second is more structured.

We have also included exploring the amount of sugar already in solution as "Part 3". In Part 3 we have the students check the time for the sugar cube to dissolve in different sugar solutions. We have also included a shorter version of this idea at the end of each of the Part 2 sections if you wish to save time (see page 5 for the inquiry approach and page 10 for the structured approach).

You may also use this activity to have students make plots of time versus temperature and/or time versus the amount of sugar in solution. The students should see relatively linear relationships in both cases.

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